M1012 REV. 0

Fuel Cell Power System Operating Manual

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Forward

Thank you for purchasing Ensol System's Fuel Cell Power System.

Please read through this reference guide before operating the unit as it contains particular start up, shut down and disconnection procedures.

If you have any questions or concerns, contact Ensol at:

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1. Ensure all fuses and/or circuit breakers are open or set to ‘Off’
2. Connect the battery leads to the batteries if required.
3. Plug the remote into the RJ45 port labeled ‘Remote’ on the fuel cell.
4. Connect fuel line to methanol cartridge.
5. Insert the exhaust tube from the fuel cell, to the water collection tank port.
6. Ensure the 2” exhaust port from the water collection tank is connected.
7. Plug the power connector into the fuel cell.
8. Close all fuses and/or circuits breakers.
9. Turn the system on using the power button the remote, or the button on the fuel cell.
10. If the display of remote control shows “Automatic“ – device is ready
11. Functionality check: Switch on device manually – check if charging starts (this is only possible if battery voltage < 13.2 V)
12. Ensure the thermostat is set at an appropriate temperature (less than 45^{o}C).
13. Remove any tools from the enclosure, store service fluid and user manual.
14. Close the enclosure and ensure that it is properly sealed.

Section 2 – General Information

2.1 Product Introduction

The Ensol Systems Fuel Cell Power System can be used to provide reliable power for measurement and control equipment, air compressors, chemical injection, communications, surveillance and a broad range of other applications.

Powered by a DMFC (Direct Methanol Fuel Cell), these packages are reliable even in the most remote and harsh environments.

These systems can be used in conjunction with other power systems. Typically Ensol ties the fuel cell packages into existing solar systems. The design philosophy then is to use solar energy when you have it, with a methanol fuel cell as a back-up when you don't. This will provide you with 100% reliable power even in the darker months of winter.

2.2 Product Specifications

	EFOY Pro 600	EFOY Pro 1600	EFOY Pro 2200
Max. Energy Output	**600 Wh/day**	**1,560 Wh/day**	**2,160 Wh/day**
Nominal Power	**25 W**	**65 W**	**90 W**
Hybrid Power Solutions	**Cascading multiple EFOY Pro units and integrating them into hybrid solar or wind packages provide significantly higher power**		
Nominal Current @12 V / 24 V	**2.1 A / 1.05 A**	**5.4 A / 2.7 A**	**7.5 A / 3.75 A**
Operating Temperature	**-20 to +45 °C (Rated to -40C in Ensol Systems Hybrid Packages)**		
Methanol Consumption	**0.9 L/kWh (0.24 US gal/kWh)**		
Dimensions (L x W x H)	**433 x 188 x 278 mm (17 x 8 x 11 in)**		
EFOY Pro Weight	**ca. 8 kg (18 lbs)**		

Section 3 System Installation

3.1 Installation Overview

The Fuel Cell Power System's electrical rating is General Purpose and shall therefore be installed outside the Hazardous location. Typically the system will be mounted 3 meters away from any source of gas and 0.6 meters off the ground.

The Fuel Cell Power System also has an exhaust port located on the bottom of the unit. In order for the unit to operate, this port shall not be blocked and needs at least a 300cm space left open below it.

3.2 Batteries

Sealed Lead-Acid batteries may be provided to store the fuel cell energy. Battery cables provide the link between the batteries, equipment and charging system. Faulty connections can lead to poor performance and terminal damage, meltdown or fire.

Batteries Inspection

- Examine the outside appearance of the battery. The tops of the batteries and terminal connections should be clean, free of dirt and corrosion, and dry.
- If fluid is on the top of a gel or AGM battery this means that the battery is being overcharged and the performance and life will be reduced
- Check battery cables and connections. Replace any damaged cables with a min. #12 AWG. Tighten any loose connections.

Changing or Disconnecting Batteries

- Use extreme caution while working on the batteries and ensure appropriate PPE is utilized.
- First isolate the batteries from the electrical system by disconnecting all fuses and/or circuit breakers.
- Disconnect the leads from the batteries, first beginning with the positive leads, then continue to disconnect the remaining batteries from one another
- When reconnecting the batteries, please ensure that they are wired appropriately for 12 or 24VDC as your electrical system requires. Wiring the batteries incorrectly can result in an over voltage condition and damage process equipment wired to the power package.
- Once the battery bank is connected, check that the voltage going to the system is within the range (dependent upon a 12 or 24VDC electrical system). If the wiring is correct and the voltage is still not within the correct range test each battery individually to see if any are defective or damaged.
- If the voltage is within the range reconnect all the loads via the fuses and/or circuit breakers.

3.3 Methanol Fuel Cell

The EFOY Pro Fuel Cell will already be mounted, but all its accessories still may need to be connected.

Connect all accessories in the following order:

- First, connect the methanol fuel cartridge(s). Screw the M28 cartridge adapter to the cartridge(s) if not already done so. Then connect the fuel line to the cartridge(s). If there is only one cartridge in the system, screw the fuel line from the fuel cell to the top of the M28 adapter. If there are two cartridges, screw the fuel line into the Duo Cart switch, then connect the two fuel lines coming from the duo cart switch to each cartridge.
- Second, connect the exhaust tubing line to the EFOY Pro fuel cell's exhaust port. This is a small tube stub protruding just next to the fuel line.
- Third, connect the wiring harness and remote to their respective ports. Ensure that the remote is plugged into the 'Remote' RJ45 port and not the 'Data' port.

Section 4 System Operation

4.1 General System Operation

The fuel cell power system is a simple package consisting of a methanol fuel cell to charge a bank of sealed lead-acid batteries. This stored electrical power is then used to run measurement and control equipment and whatever other loads may be involved. A typical hybrid application where the fuel cell is connected in parallel with a solar system is illustrated in Figure 1.

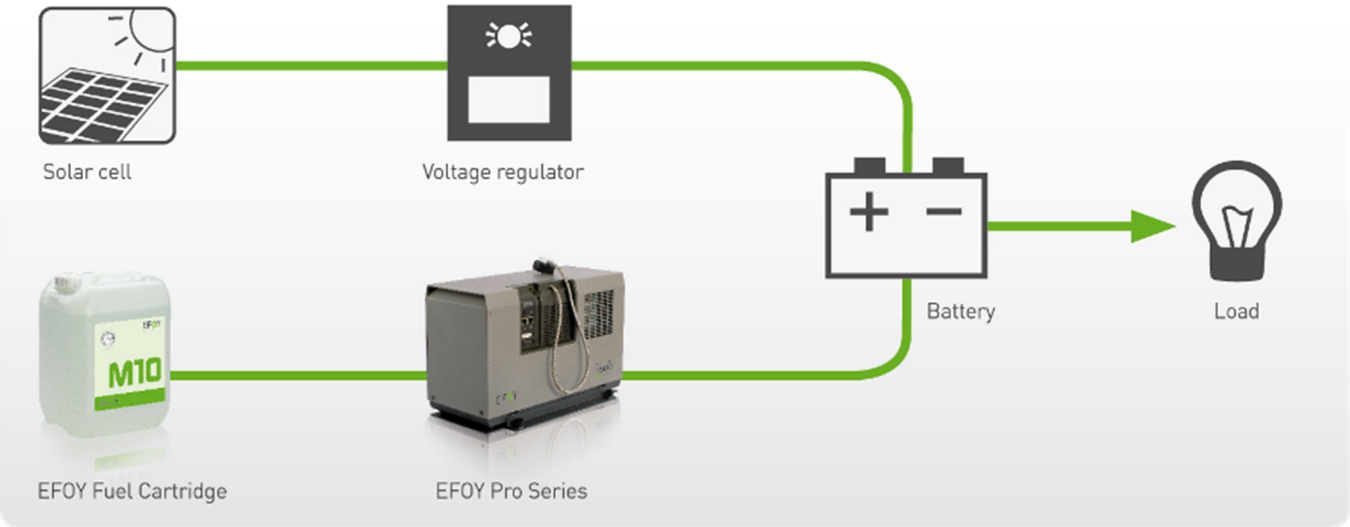
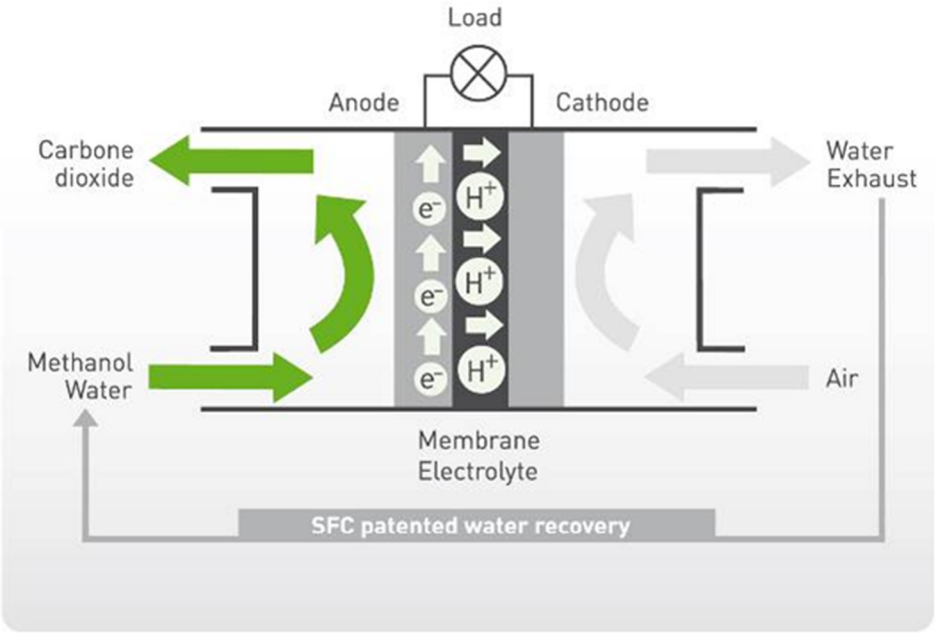


Figure 1 – Hybrid System

4.2 Fuel Cell Operation

The SFC EFOY Pro fuel cell uses a catalytic process to directly convert methanol into electricity (see Figure 2). The byproduct of this reaction is water, small amounts of CO_2 and heat. To eliminate freezing, the water must be collected internally. The collected water should be changed out at the point in time that the fuel cartridge is replaced.



Methanol + Oxygen → Carbon dioxide + Water vapor

$2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$

Figure 2

Since the EFOY Pro fuel cell is a 'smart' fuel cell, charging and monitoring to the batteries is handled automatically (example in Figure 3). With the remote which is included, the user can view the charging mode, battery voltage, charging current, system operating hours and firmware version, and can also change the charging mode. By pressing the power button on the remote, the user can turn the system off, put it in automatic or turn the system on for one charge cycle.

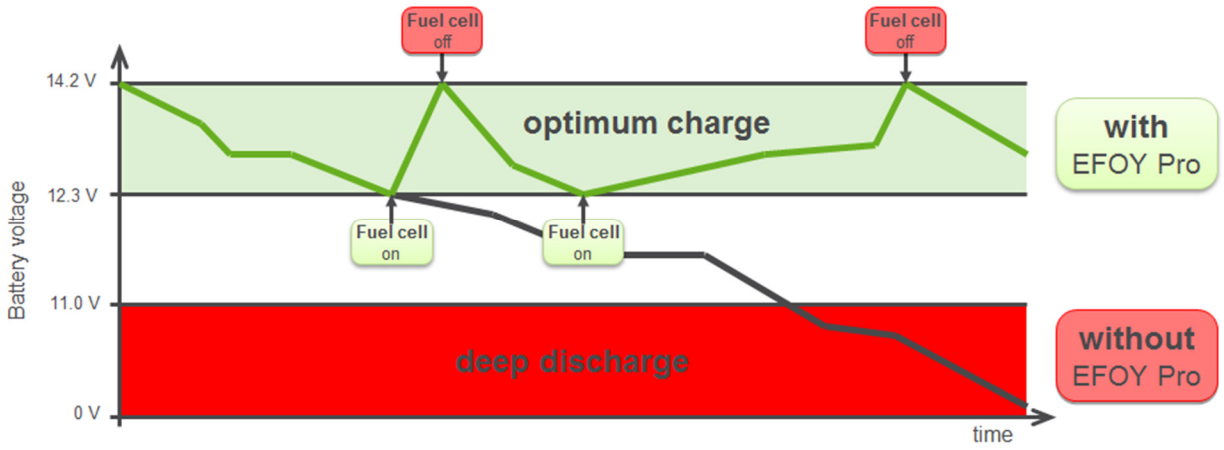


Figure 3

Ensol Systems has pre-programmed the fuel cell's parameters for the installation location. If charging voltage set points need to be altered, please contact Ensol Systems.

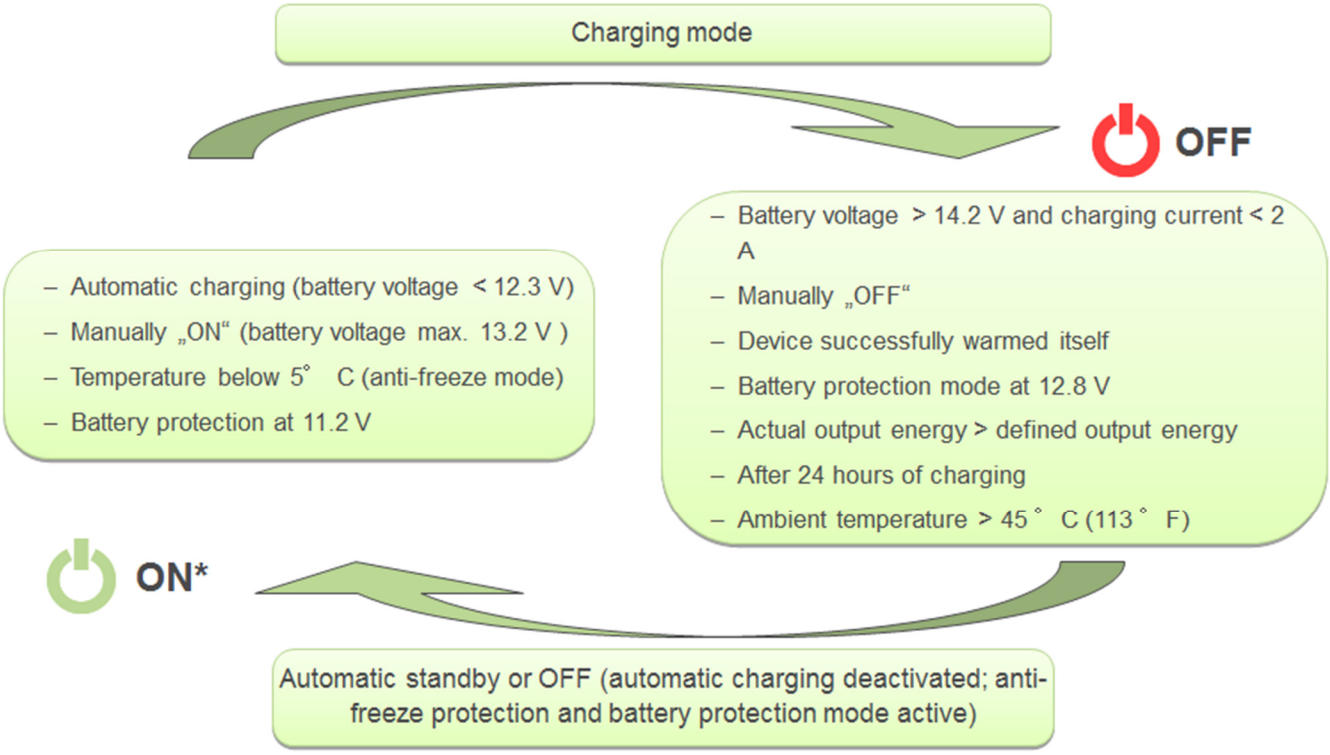
For a full description of the EFOY Pro fuel cell's operation, please see the manual provided by SFC's document 101123_UM_EFOY_Pro_GB_v02.

4.3 UN Certified Methanol Fuel Cartridges

The EFOY Pro uses special plastic fuel cartridges to facilitate ease of use and transport:

- The methanol fuel cartridges are UN certified containers certified for transport on cargo planes.
- The containers are spill resistant and designed to withstand significant impact force.
- Ensol Systems will recycle empty plastic cartridges and dispose of any residual methanol if necessary.
- 28L cartridges are the largest available size and a cartridge adapter is required to use this cartridge with the EFOY Pro fuel cell. DO NOT THROW AWAY THE CARTRIDGE ADAPTER!
- The fuel cell methanol is ultrapure. Do not puncture the cartridge. To avoid contamination, do not transfer residual methanol from an old cartridge to a new cartridge. DO NOT USE ANY OTHER METHANOL SOURCE TO FUEL THE EFOY PRO! Impure/contaminated methanol will severely degrade the performance and life of the EFOY and will **VOID WARRANTY**.

4.4 Operational States

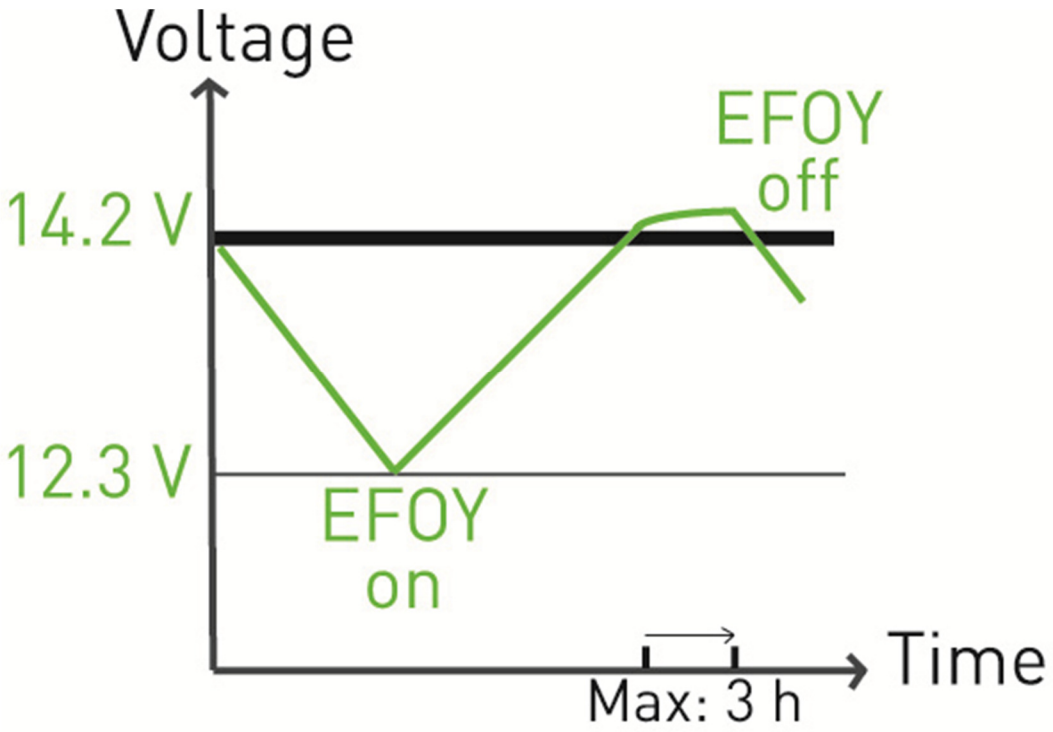


- Note that a minimal battery voltage of 9.0V or 18.5 V is required for the EFOY Pro to start.

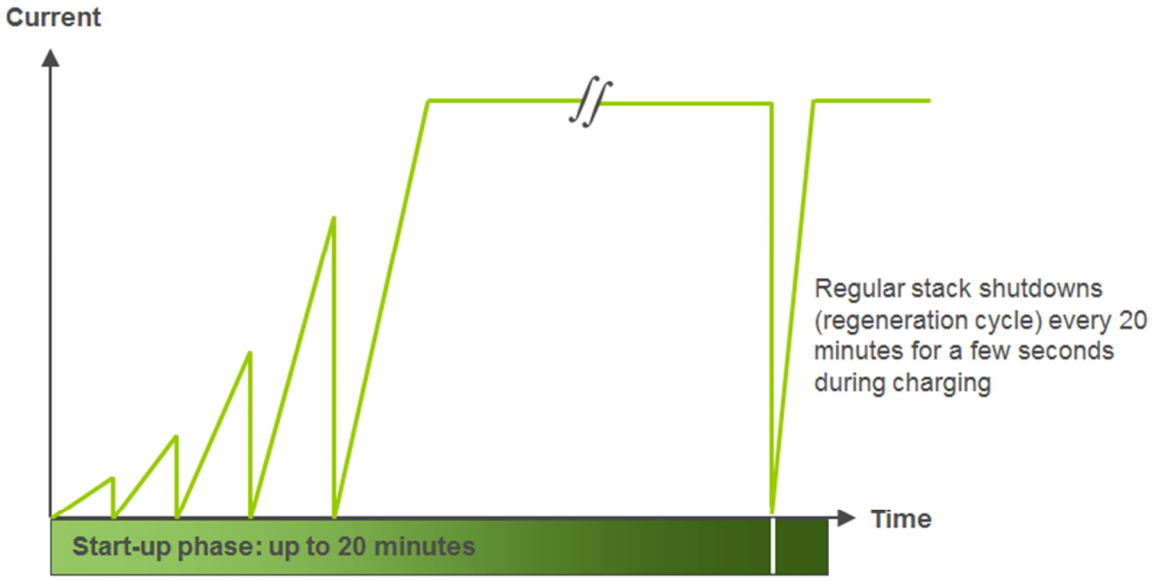
4.5 Default Parameters of cutoff threshold

New charging strategy (firmware 9.20 since mid of August 2010):

- Switch on voltage: 12.3 V (11.0 - 13.0 V)
- Switch off voltage: 14.2 V (13.5 - 14.7)
- Switch off current: 2 A / 4 A @ EFOY Pro 2200 (0.5 - 10 A)
- Switch off time: 3 hours (0 - 5 hours)
- This ensures full battery charging and maximizes battery life

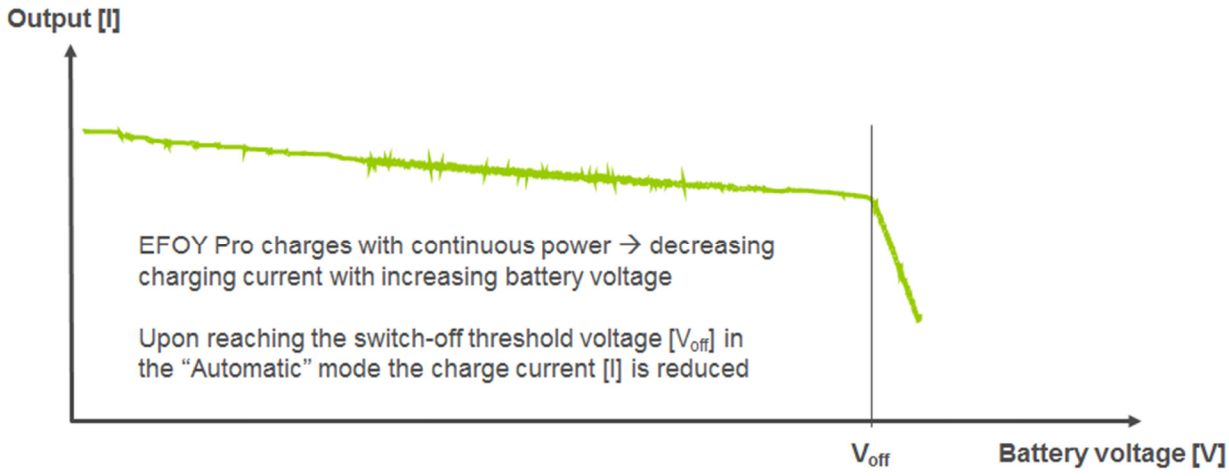


4.6 Startup and Shutdown Phases



Note:

- Device needs a start-up phase of 10 -20 min to achieve full power
- During start-up phase several starts until full power is achieved



End of charging

- The switch-off process allows a controlled disconnection of the EFOY Pro Fuel Cell
- The switch-off process may take up to 30 minutes
- Avoid interrupting the switch-off process!

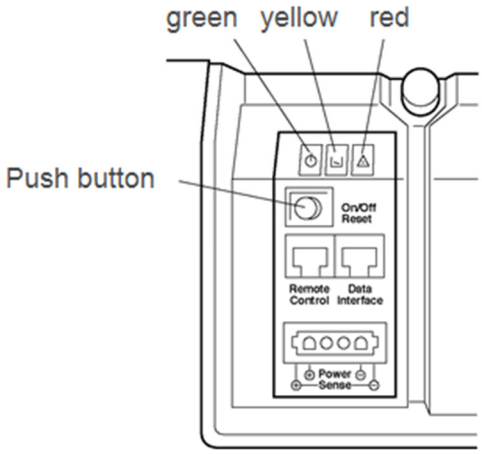
4.7 Anti–Freeze Protection Mode

- Note that the standard Ensol Systems Fuel Cell Power Packages are rated to -40C operation.
- THE ANTI-FREEZE PROTECTION MODE WILL NOT WORK WITHOUT FUEL! Please ensure that the fuel cell does not run out of methanol in freezing temperatures. If the fuel cell freezes, 24 hours will be required for the fuel cell to warm back up and be returned to service.
- The Anti-Freeze Mode will keep the EFOY Pro warm while the temperature is below 5°C (This will work even when the unit is "OFF").
- Anti-Freeze Mode requires the connection to a faultless, adequately charged battery and fuel cartridge.
- Fuel consumption will be dependent upon external temperature differential. Weather, insufficient insulation, ambient temperature and operating mode can have an impact on fuel consumption.
- The EFOY Pro does not give the produced energy to a fully charged battery in Anti-Freeze Mode. Rather, the stack "burns" methanol and supplies the peripheries (pumps, etc…) to heat up the system. The batteries will not be overcharged.
- The EFOY Pro can operate in -20 °C temperature. Proper heat management and insulation is required to ensure reliable operation at -40 °C.
- Startup temperature (when the Anti-Freeze Mode has not been activated) is 5 °C.

4.8 Operation at the Device

Push button

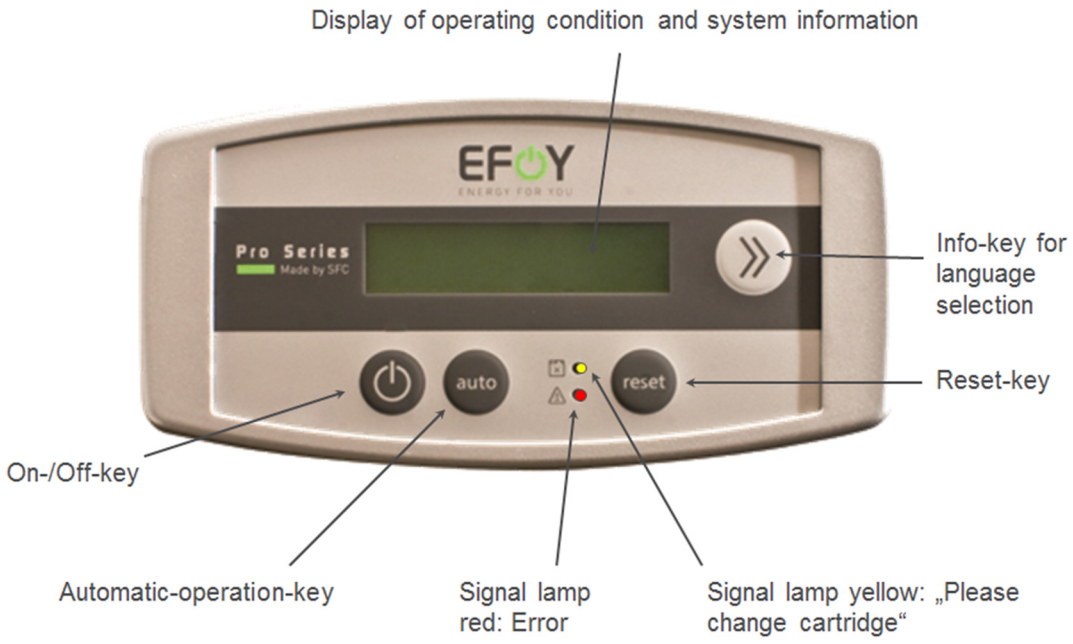
	Result
Push shortly (< 0.5 s)	Reset
Push longer (> 3 s)	On/Off



LED state

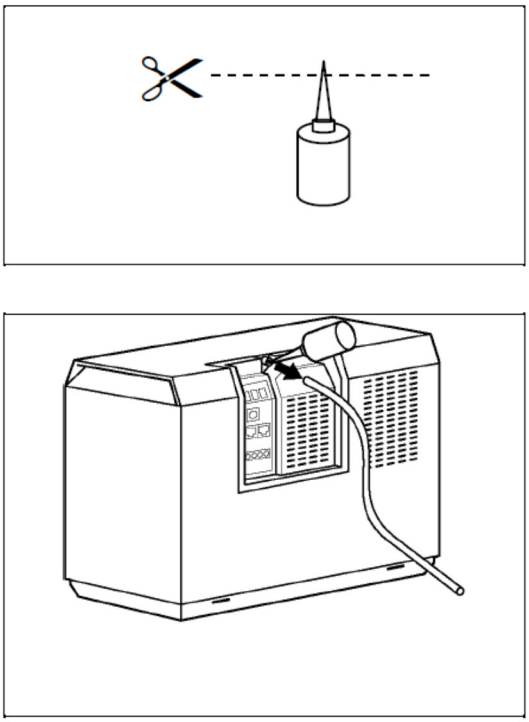
	Green	Yellow	Red
On	Ready	Add service fluid	Error
Blinking	Shutting down	Cartridge empty	Interruption
Off	Off or error	No error	

Remote Control:



4.9 Service Fluid

- If service fluid is low the yellow light will turn on at the EFOY Pro and the message “Please refill service fluid” will appear at the control panel display.
- Normally, there is no need to add service fluid prior to the initial start-up.
- Note that the fuel cell produces its own service fluid during operation. This is critical to the function of the device. If the EFOY Pro is operated continuously at temperatures above the acceptable operating range (45 °C), the service fluid will be expelled faster than it can be regenerated and cause a failure. For this reason, it is critical that the thermostat and fan provided with the Fuel Cell Power Package are maintained in working order and set at an appropriate temperature.
- Service fluid can be added by removing the exhaust line as pictured below.



4.10 Battery Connection

Power lead

- Carries current from the fuel cell to the battery

Length	Cross section
< 5 m	2,5 mm²
5 – 10 m	6,0 mm²

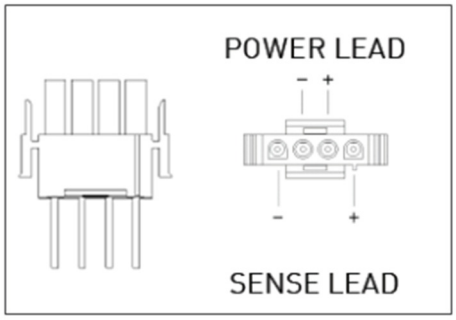
Sense lead

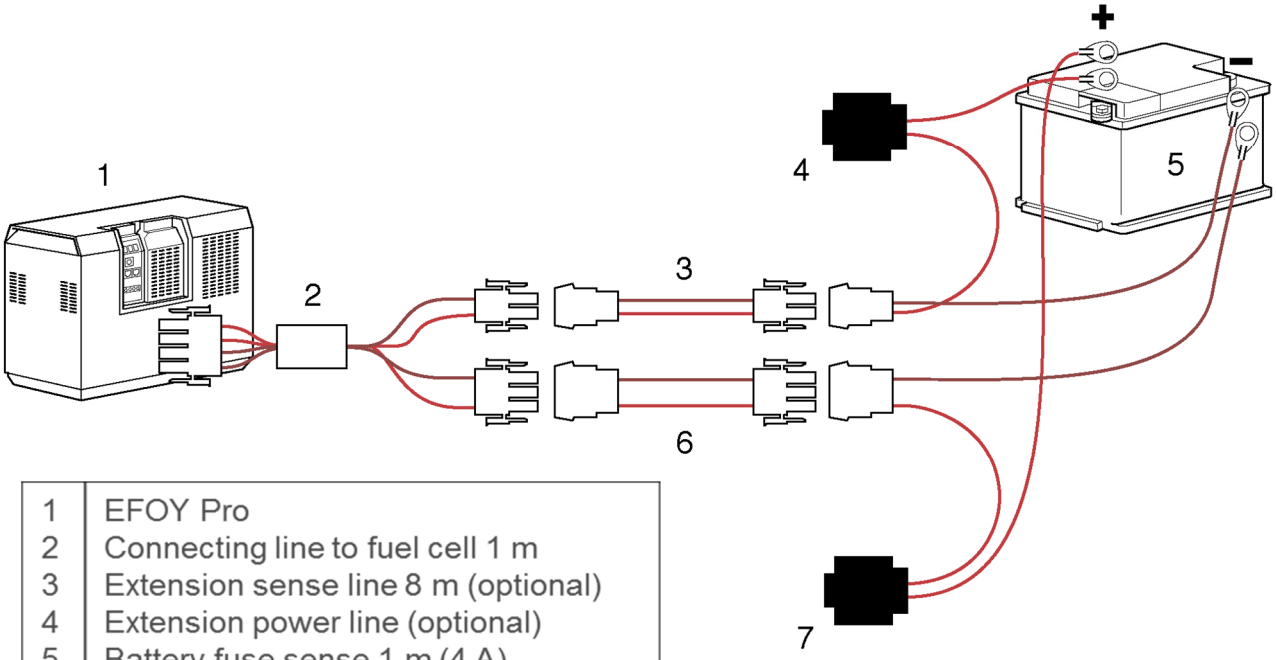
- Measures battery voltage
- Connection as close to the battery as possible

Length	Cross section
< 5 m	min. 0,5 mm²
5 – 10 m	1,5 mm²

Note

- Power and sense lines must contain fuses
- 8 m extension sense line and power lines available





1	EFOY Pro
2	Connecting line to fuel cell 1 m
3	Extension sense line 8 m (optional)
4	Extension power line (optional)
5	Battery fuse sense 1 m (4 A)
6	Battery fuse in power line 1 m (15 A)
7	Battery

Section 5 Error Messages

5.1 Error Classifications Ranges

- 10 Internal hardware or firmware issue - Contact Ensol Systems.
- 20 Fuel - Change the cartridge and reset.
- 30 Service Fluid - Add service fluid and reset. Check thermostat and fan function.
- 40 Environmental Issue – Temperature too high or too low to maintain function.
- 50 Battery - Battery voltage too high or low. Check connections. Check solar charge controller.
- 70 Reservoir - Internal fuel problem. Check fuel connections and reset.
- 80 System - Internal voltage or system error. Reset.

5.2 Error Types

- A = Automatic reset (after error cause is remedied)
- M = Manual user intervention required
- F = Anti-freeze protection is possible from this error, if the error cause currently no longer exists
- P = Permanent error (not resettable)
- R = Reset required to restart system
- W = Warning

5.3 Most Common Error Messages

- 12, 13, 14 - Failure due to blocking of exhaust or circulation pump defect.
- 32, 31, 30, 41 - Failure due to high surrounding temperature. Check installation and ensure air circulation is adequate.
- 52-54 - Check battery (voltage too low) and/or battery connection problem
- 72, 76 - Failure in Methanol dosing or internal sensors. Possible issues in Methanol cartridge because of fuel line.

Display message	Error code	error type	Error description	Remedial measure	Potential error causes	Notes
Please contact service	1	P	System configuration incomplete	Repair by SFC required	Firmware update failed	
	10	P	Serious system error	Repair by SFC required	Stack damaged	
	15	P				
Please contact service	13	A (1x / 30s) R F	Stack power output too low	Press RESET (max. 3 attempts), repair required if error reoccurs	Hardware defect	
	14	A (1x / 30s) R F	Fluid level sensor defect			
	17	R F	Abnormal power difference between stack and output			
Please check exhaust hose	11	A (1x /30s) R F	Stack voltage too low (error 11: during operation, error 18: during start-up)	Solve potential error cause, then press RESET (max. 3 attempts)	Exhaust hose blocked, not sufficient fresh air	Test: disconnect exhaust hose and press "Reset", if fuel cell is now running the exhaust hose is blocked
	18	A (3x / 300s) R F				
Please change fuel cartridge	20	M R F	Empty fuel cartridge detected (internal fuel sensor)	Change fuel cartridge (solve error cause) then press RESET	Error causes if fuel cartridge not empty: - Bad connection of fuel cartridge connector (air leak) - Dirty fuel cartridge connector	
	22	M R F				
Please refill service fluid	30	M R F	Low service fluid level (error 30: <20%, error 31: <5%)	Add service fluid (solve potential error causes) then press RESET	- Operation at high ambient temperatures or insufficient cooling air	
	31	M R F			- Fluid level measurement defect	
Interruption: Surroundings too warm	32	A F	Service fluid level below 40%	Wait (until temperature has dropped)	-Ambient temperature to high (avoid direct sunlight) - Poor air ventilation in installation space	
	41	A F	Temparature to high (internal sensor)			
Interruption: Please defrost device slowly	40	A M	Temperature too low (stack temperature sensor < 3 °C)	Defrost unit (ca. 24 h at room temperature)	- Anti-freeze protection did not work (due to an error)	
Please check battery voltage	50	A F T	Battery voltage too low (sense line)	Solve error cause (check battery and connections)	Battery voltage < 10,5 / 21 V -> charge with battery charger	
	51	A	Battery voltage too high (sense line)		Battery voltage > 16,5 / 33 V -> check external battery charger and disconnect if necessary	
	52	A	Batttery voltage too low (power line)		Check connection to battery: - Check battery cables - Check battery fuses	
	53	A	Battery voltage too high (power line)			
Please contact service	54	A	Battery voltage measurement defect	If the error persists a repair is required	Circuit Board defect	
	70	R	Error fuel reservoir sensors	Press RESET (max. 3 attempts), repair required if error reoccurs		
	73	R	Internal fuel sensor defect			
	75	R	Reservoir error (emptying time too long)			
	80	R	Internal voltage reference out of tolerance			
	83	R	DC/DC-Transformer defect			
	84	R A	Self test equipment			
	76	P	Serious reservoir error	Permanent error - repair required	- Error 70 or error 72 reoccurred 3 times	

Please check fuel cartridge connector	72	A M F R	**Reservoir error (refilling time too long)**	**Solve potential error cause,** then press RESET (max. 3 attempts)	**- Firmware problem (FW <9.11)** - Bad connection of fuel cartridge connector (pumps air) - Dirty fuel cartridge connector	Firmware update recommended (fixed with FW 9.11 or higher)
Please install Filter XT	38	W	**Filter EFOY XT is removed**	**install Filter**		only EFOY 2200 XT
Please contact service	85	R	**Filter-Circuit-Board EFOY XT not detected**	**Press RESET (max. 3 attempts), repair required if error reoccurs**		only EFOY 2200 XT
no display information	137	A	**Filter change confirmed**	**no action required**		only EFOY 2200 XT
Please change Filter XT	139	M	**Filter change is displayed**	**change Filter EFOY XT**		only EFOY 2200 XT
no display information	90	A	**Antifreezemode successfully**	**no action required**		
Update: DO NOT UNPLUG BATTERY	99	A	**Firmware update is performed**	**not interrupt firmware update**		
no display information	140	A	**Antifreezemode not possible**	**fix other error**	**another error is blocking the antifreezemode**	
no display information	172	A	**Error 72 was once ignored**	**no action required**		
no display information	184	A	**Self test equipment successfully**	**no action required**		
Firmware corrupt update required	without	A	**transfer defective firmware**	**repeate firmware-update**		
No connect or Check battery	without		**Remote control has no connection to fuel cell**	**Check connection, load battery if necessary**	- Remote control is connected to wrong port (Data Interface) - Batter voltage < 8,5 V - No communication (defect)	